AD-A127 870 ELECTRONIC TIME SWITCH EVALUATION STUDY(U) CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL L R THURBER MAR 83 CERL-TR-E-184 1/1

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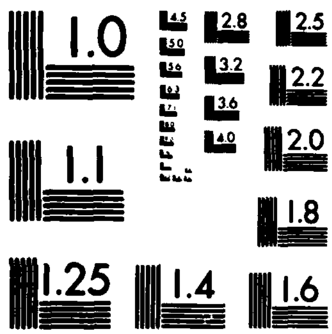

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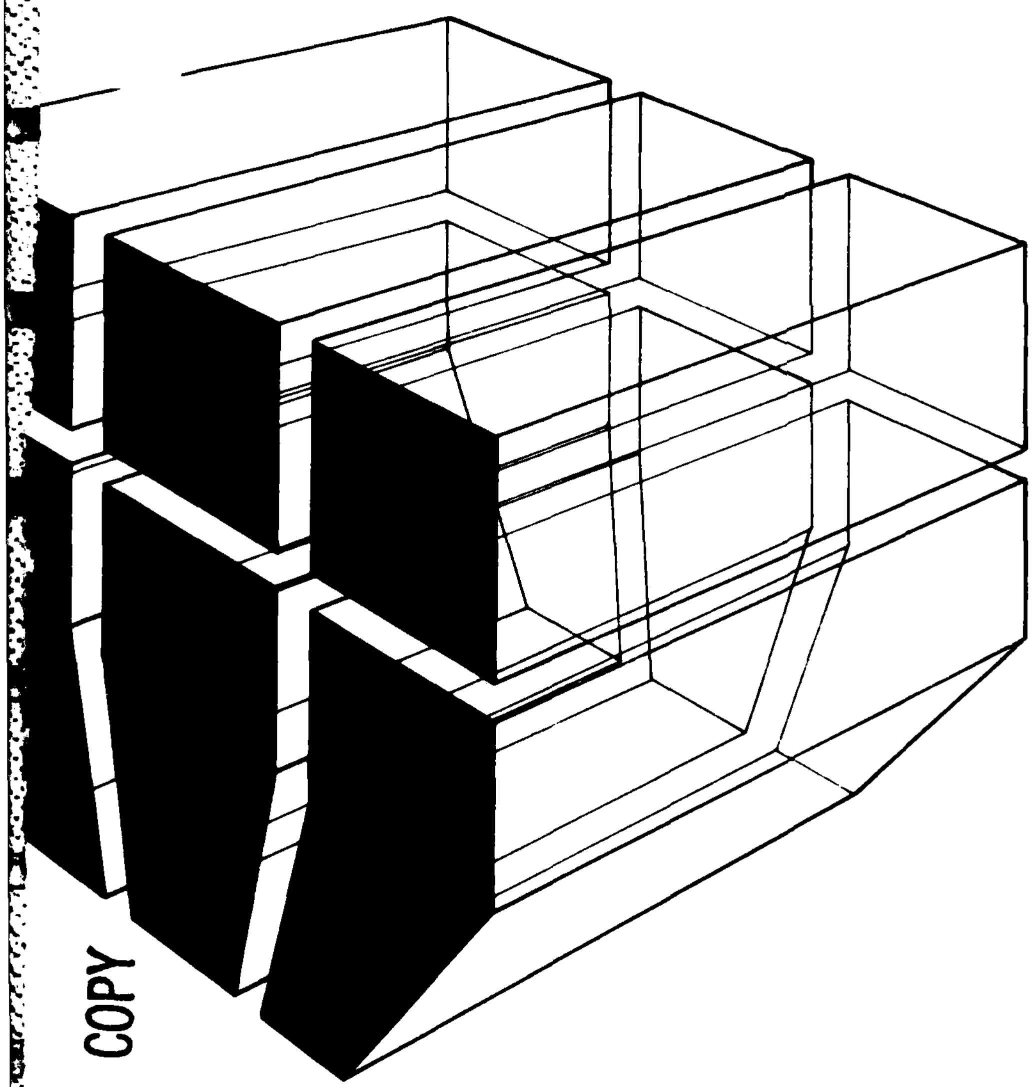
TECHNICAL REPORT E-184
March 1983
Strategies for Controlling Energy Use in Existing Facilities

ELECTRONIC TIME SWITCH EVALUATION STUDY



by
Lee R. Thurber

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CERL-TR-E-184	2. GOVT ACCESSION NO. AD-A127 870	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Electronic Time Switch Evaluation Study		5. TYPE OF REPORT & PERIOD COVERED FINAL
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Lee R. Thurber		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. BOX 4005, CHAMPAIGN, IL 61820		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A762781AT45-B-004
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE March 1983
		13. NUMBER OF PAGES 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are available from the National Technical Information Service
Springfield, VA 22161

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Buildings
electric power
energy consumption
time switches

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a study which tested and evaluated the feasibility of using electronic time switches to reduce the electrical energy consumption of Army buildings which may not be suited to other energy-saving techniques like the Energy Monitoring and Control System. The study emphasized heating, ventilating, and air-conditioning (HVAC) system controls in office and community support buildings. Electronic time switches were installed in 12 buildings at Fort Carson, CO, and Fort Knox, KY. Test

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results showed savings of between 12 kWh and 99 kWh per day of the electrical energy consumed in the test buildings. Payback periods ranged from 5 months to 3-1/4 years. This report also includes guidance on selecting and installing electronic time switches on HVAC system controls.

FOREWORD

This report was prepared for the Assistant Chief of Engineers, under Project 4A-762781AT45, "Energy and Energy Conservation"; Task B, "Installation Energy Conservation Strategy"; Work Unit 004, "Energy Conservative Operation of Existing Buildings and Facilities." The Technical Monitor is Mr. B. Wasserman, DAEN-ZCF-U.

The work was performed by the Energy Systems (ES) Division of the U.S. Army Construction Engineering Research Laboratory (CERL). Mr. R. G. Donaghy is the Chief CERL-ES.

Ms. B. Elischer, Mr. R. Neathammer, and Mr. L. Windingland of CERL made major contributions to data collection and evaluation during this study. Appreciation is also expressed to Mr. Thomas Hutchins and Ms. Victoria Stemptowski of the Directorate of Engineering and Housing (DEH) at Fort Knox, KY, and Mr. Ronald Wilhelm and Mr. Robert Bell of the DEH at Fort Carson, CO, for their outstanding support in installing test equipment and during the data collection for this study.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

ELECTRONIC TIME SWITCH EVALUATION STUDY

1 INTRODUCTION

Background

Since the energy crisis of 1973-74, the continually increasing cost of energy has drained a disproportionate amount from Army installation operational funds. Although the Army reduced the use of fossil fuels for heating by 20.9 percent from 1975 to 1981 (from 112,230,485 to 92,899,055 MBtu*), electricity use decreased only by 0.17 percent (from 8,658 to 8,044 BWh), and in fact rose by 3.2 percent between 1979 and 1981.[1]

Between 1975 and 1981, the cost of electricity increased by 132 percent. Facility Engineers and major commands (MACOMs) have not yet been able to effect any major reductions in electrical energy consumption partly because they lack specific reduction measures.[2] However, a recent Engineering Technical Note (ETN) states that "many actions can be taken to reduce the total (of electrical energy consumption) or at least to prevent the total from becoming even more astronomical than it is."[3] Most electricity at Army installations is used for lighting, HVAC systems, appliances, and motors. A recent study by the U.S. Army Construction Engineering Research Laboratory (CERL) found that "a large percentage (50 to 70 percent) of total annual electricity consumption is attributed to the magnitude of the minimum baseline consumption (lowest hourly demand/consumption). The baseline is attributed to HVAC fans and pumps that operate continuously."[4] During the same study CERL conducted limited tests of one electronic programmable time switch over a 4-week period. The test results indicated that the switch had great potential for reducing energy consumption in certain types of facilities. A large-scale test, however, was needed to validate these results and to obtain data on the performance, reliability, maintenance requirements, and problems that might be encountered when using an electronic time switch in an operational environment.

Objective

The objective of this study was to test electronic time switches in an operational environment for 1 year and provide guidance to the Facilities Engineers (FE) on their effectiveness and applications.

Approach

1. Catalogs and other literature were reviewed for state-of-the-art information on electronic time switches. Based on this review, a time switch was selected for testing.

2. Installations and buildings were selected for the operational test. Electronic time switches and electrical metering and recording packages were installed at selected building sites.

3. Operating schedules were prepared. Electrical power consumption data were collected by the metering packages.

4. Collected data were processed and analyzed.

5. Recommendations for selecting and installing electronic time switches were prepared.

Mode of Technology Transfer

It is recommended that information from this study be used to prepare an Engineer Technical Note recommending methods and procedures for using electronic time switches.

2 DISCUSSION

General

The advance of microcomputer technology in the past few years has brought with it the concept of using microengineering to conserve energy by automatically controlling HVAC system operation. CERL's earlier study indicated that if major electricity consumers like

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*Metric conversion: 1 MBtu = 1.055 GJ.

[1] *Facilities Engineering Annual Summary of Operations* (Department of the Army, Office of the Chief of Engineers FY75, FY79, and FY81).

[2] *Army Facilities Energy Plan* (Department of the Army, 1980).

[3] *Conserving Electrical Energy*, ETN 81-4 (Office of the Chief of Engineers [OCE], April 1981); *Energy Conservation and Proper Lighting*, ETN 80-17 (OCE, September 1980 [Suppl 1, April 1981; Suppl 2, June 1981; Suppl 3, September 1981]).

[4] L. M. Windingland, Technical Report E-170/ADA100837, *Electrical Energy Reduction for Army Installations* (U.S. Army Construction Engineering Research Laboratory (CERL), 1981).

HVAC equipment were time-scheduled, building electrical consumption could be cut by as much as 30 percent.[5]

The most sophisticated form of HVAC, lighting, and equipment control in the Army today is the Energy Monitoring and Control System (EMCS). However, EMCS is not practical for use in all Army buildings because of the line distances involved from the EMCS central controlling point, the small number of points to be controlled, or cost. Where the EMCS cannot be justified because of cost, size, or distance, simpler and cheaper equipment like the electronic time switch may be justified.

The electronic time switch is a device which can turn electrically controlled devices on and off at predetermined times. It is a step backward from the EMCS, but a step forward in the state of the art of mechanical time clocks; its solid state electronic circuits make it far more sophisticated than mechanical clocks. For example, an electronic time switch can be programmed to control multiple circuits with different on/off cycling. Most switches can also be programmed to omit or change the cycling on specified days of the week. A few can be programmed to change the on/off cycle on holidays throughout the year. Generally, from two to 16 circuits can be controlled by one switch, depending on the type chosen.

The main reasons for using electronic time switches are:

1. To replace and extend the use of mechanical time clocks where EMCS systems are not installed or not feasible. An electronic switch conserves energy by turning off equipment at the times of the day or week when it is not needed. Existing control systems often let HVAC units operate 24 hours a day even if the space served is unoccupied. Electrical energy used for the air handling fans and heating and cooling energy can also be saved by turning the fans off when they are not needed.

2. To control HVAC systems when manual controls are inadequate. In many cases, manual on/off controls are not satisfactory because (a) they are not easily accessible, (b) building personnel do not know enough about the HVAC system to properly operate it, (c) the building (in particular classroom buildings) is occupied by constantly changing groups who have little or no experience in operating the HVAC systems, or (d) the system needs to be controlled when no personnel are in the building.

Test Plan

The electronic time switch was to be used in an operational environment to determine if it would save electrical energy. To predict probable savings, it was necessary to compare the electrical energy use of a building *with* an electronic time switch in use with a control building where a switch was *not* being used. Three methods for establishing a test control were considered.

The first method was to select a building that was identical or nearly identical to the test building and use it as a control. This is difficult to do because not only must the buildings themselves be identical, but other factors which affect electrical consumption must be nearly identical. These include building orientation, shielding from wind, number of occupants, equipment, etc. Thus, to get good data, a large sample and extensive measurements of wind forces, building occupancy rates, equipment-use profiles, etc., are required.

The second method was to take many buildings which are nearly identical and split them into two groups, one group to be used for switch testing and one group as a control. If these groups are large enough, the differences will tend to cancel out. This method requires a large number of buildings.

The third method, the one chosen for this test, was to use each building as both a control and a test. In this method, the switch is operated for a given period of time, then not operated for a similar period. Since the energy use in most buildings is significantly different between weekends and weekdays, the test-control period should be at least 1 full week. Because the same building is used for both a control and a test, building characteristics and controlled loads remain the same and do not affect the test results. In addition, by using a large number of test-control periods, the effects of uncontrolled variables (like weather and building occupancy patterns) will tend to average out.

Uncontrolled variable effects are further minimized by dividing the buildings into two groups and having half the switches in use while the other half are disconnected. The test was run for a year so that the effects of seasonal loads (unit heaters, air conditioning,

[5] L. M. Windingland, Technical Report E-170/ADA100837, *Electrical Energy Reduction for Army Installations*, (CERL, 1981).

Table 1
Buildings Selected for Switch Installation
FORT CARSON

Description	Post Bldg Number	Area	Equipment controlled
Enlisted Mens Club	1230	27,743 sq ft	Air-handling units
Noncommissioned Officers Club Annex	1354	4,608 sq ft	Fans, boiler, pumps
Indoor Pool	1446	8,872 sq ft	Air-handling units, boilers, water and filter pumps
Commissary	1525	86,015 sq ft	Air-handling units, unit heaters
Gymnasium	1856	23,159 sq ft	Air-handling units
Battalion Headquarters	2060	22,065 sq ft	HVAC fans, pumps, water heater
Mess Hall	2461	10,492 sq ft	Air-handling units
Bachelor Officers Quarters	7304	36,638 sq ft	Boiler, pumps

FORT KNOX

Description	Post Bldg Number	Area	Equipment controlled
Gymnasium	850	24,852 sq ft	Air-handling units
Classroom Building	1171	4,320 sq ft	Air-handling units
Classroom Building	1172	4,320 sq ft	Air-handling units
Maintenance Shop	6592	8,400 sq ft	Unit heaters

etc.) would be included in the collected data. The thermal energy used for heating and cooling the test buildings was not measured.

Site and Building Selection

Fort Carson, CO, was selected as the prime site for the test because a representative sample of buildings of various military consumer groups performing different installation functions had been installed with metering and recording instruments for CERL's earlier study.[6]

The seven consumer groups identified in that earlier study were: (1) troop housing, (2) family housing, (3) administration/training buildings, (4) production/maintenance buildings, (5) storage buildings, (6) medical/dental buildings, and (7) community support facilities.

Fort Knox, KY, was selected for limited testing to enhance the results obtained at Fort Carson.

Building selection was mainly based on (1) covering as many of the seven building groups as practical and (2) selecting buildings which were not occupied for definite periods of the day or week. Based on the above, troop housing, administration/training, production/maintenance, and community support facilities were considered the best candidates for electronic time switches. Family housing was not selected because it had no predictable unoccupied periods. Storage buildings were not selected because they had limited heating and air conditioning. Medical and dental buildings were not selected since they are normally cost-effective candidates for EMCS.

Further selection criteria were based on the characteristics of the buildings' central HVAC systems and their control ease. (Facilities with air-distribution types of HVAC systems are preferred to systems with individual room fan/coil systems because fan/coil system control circuits tend to be very decentralized.) The buildings at Fort Carson which already had metering packages installed were given selection priority. The estimated electrical energy use in the selected buildings was calculated. An example of the calculations is given in the Appendix. Table 1 lists the buildings selected for the switch tests. CERL personnel visually inspected these buildings to define access to HVAC control circuits and to determine the possible constraints for installing the switches and metering packages, the physical protection of the equipment, and current building use and occupancy patterns.

[6] L. M. Windingland and B. N. Sliwinski, Interim Report E-143/ADA066513, *Fixed Facility Energy Consumption Investigation* (CERL, 1978).

Table 2
Typical Electronic Time Switch Units

Feature	Manufacturer A	B	C	D	E	F
Approximate Cost	$300	$2000	$10,000	$4,000	$700	$2300
Circuits	4	8	8	16	4	1
No. of Programs	10	512 (8 per day per circuit)	64	64	1 circuit per day	1
Tamper Protection	Locking Keyboard	Program Lock	Memory Lock		Cabinet Lock	Cabinet Lock
Battery Backup	Yes	Yes	Yes	Yes	Yes	Yes
Override Capability	Manual External	Manual Internal	Internal	Manual Internal	Manual External	No
Construction	Steel Case	Steel Case		Steel Case	Steel Case	Steel Case
Heating/ Cooling Advance	No	Yes	No	No	No	Yes
Holiday Option	No	Yes	No	No	No	No

Equipment Selection

Table 2 summarizes the pertinent parameters of electronic time switches made by six different manufacturers. The least expensive switch was versatile enough to control most of the HVAC equipment and other equipment used in this test. In cases where additional circuits were needed, CERL designed and built a low-cost relay control box. In no case did CERL need more than 10 programs. As Table 2 indicates, there was not much variation in the other switch parameters.

The following features are important for any electronic time switch chosen for use in Army buildings:

1. The switch's overall cycle time should be at least 1 week. The timer should be a quartz-crystal-controlled unit or have similar accuracy.

2. The switch should be programmable for different on/off cycles for weekday and weekend periods.

3. The switch should have battery backup power for the switch timing circuits (clock) and program memory in case of electrical power failure. The battery backup should be rated for a time equal to the maximum expected length of a power outage at the installation.

4. The switch should have a contact rating capable of handling the controlled load, or auxiliary relays must be installed with the proper load rating.

5. The switch should have a manual override. In addition, it should be capable of having a low-temperature (freezestat) thermostat connection installed to override its switching.

6. The switch should be protected against vandalism. It should be installed in a secured area (such as a locked mechanical room) or in a locked security cabinet.

7. The switch will need a semi-annual maintenance inspection. This may be done at the time of the daylight savings time change. For some applications, its clock may also need to be changed at this time. The inspection should consist of:

a. A visual inspection to check for damage or vandalism. The wiring to the controlled circuits and the mounting box should be inspected as well as the switch itself.

b. A check of the standby battery for corrosion and low voltage. The battery should be replaced, if needed.

c. A check of the switch's indicated time. Since the inspection will normally occur at the daylight savings time change, the switch's time will probably need to be changed.

d. A check of the switch's program against the program sheets. The program should then be corrected, if necessary.

A pulse-initiating watthour meter and pulse recorder were installed to monitor the electrical power consumption on the selected buildings. The pulse recorders place time and power consumption data on magnetic tapes which can be interpreted and analyzed by computers at CERL. Figure 1 is a diagram of the equipment connection.

Data Collection

Data were initially collected using the pulse recorders and the pulse-initiating watthour meter. The pulse initiator on the watthour meter puts out pulses proportional to the power consumption measured by the watthour meter. The pulses are sent to the pulse recorders where they are placed on magnetic tape. The pulse recorder also places periodic timing pulses on the ma[illegible]ic tape. Once a month, during the test, the magnetic tapes were removed from the recorders by installation personnel and mailed to CERL. Data collection was continued for 1 year. Figure 2 shows a diagram of the data flow.

The magnetic tapes were read by a magnetic tape reader into a DEC PDP-11 computer. Data were printed out giving daily and hourly electrical power consumption. Monthly power consumption profiles were then plotted. Figure 3 shows example plots of electrical power consumption. All the monthly data for each building were put into one file and formatted so they could be used for later analysis.

3 DATA ANALYSIS AND RESULTS

Analysis Procedure

The first step in analyzing the collected data was to total the hourly electrical power consumption for each building for each day. The number of days of data obtained for each building is in Table 3 as "Days of Data." The daily power consumption totals were then divided into groups depending on whether the switch was in use ("ON") or not in use ("OFF") in the building for that day. The daily totals in kilowatt hours per day in each group were then averaged and the averaged entered in Table 3. The "ON" average daily power consumption was subtracted from the "OFF" average daily power consumption and entered as the difference. The difference (in kilowatt hours per day) was multiplied by 365 to give an estimate of the electrical energy (in kilowatt hours) that could have been saved if the switch had been used for a full year. This value was multiplied by an approximate cost of electricity to obtain an estimated cost savings for each electronic time switch installed. An electrical cost of \$0.05/kWh was used in this report to calculate savings but each installation may have different rates. An estimated straight line payback period was calculated using an installed cost of \$700 (switch \$300, mounting box \$75, freezestat \$50, relay etc. \$50, and labor \$225).

To determine if using an electronic time switch affects electrical energy use differently on the weekends than on weekdays, the daily data were further subdivided:

1. "ON" weekday data.

2. "OFF" weekday data.

3. "ON" weekend and holiday data.

4. "OFF" weekend and holiday data.

Table 4 summarizes the average daily power consumption for each data group. If the data in Table 4 were used to calculate estimated savings, the results would not be significantly different from the results given in Table 3.

Results

Fort Carson

At Fort Carson, electronic time switches were installed in eight buildings: (1) Building 1230, an Enlisted Mens (EM) Club; (2) Building 1354, the Noncommissioned Officers (NCO) club annex; (3) Building 1446, the indoor swimming pool; (4) Building 1525, the main commissary; (5) Building 1856, a gymnasium; (6) Building 2060, a two-battalion headquarters and classroom building; (7) Building 2461, a dining facility; and (8) Building 7304, a female bachelor officers quarters (BOQ).

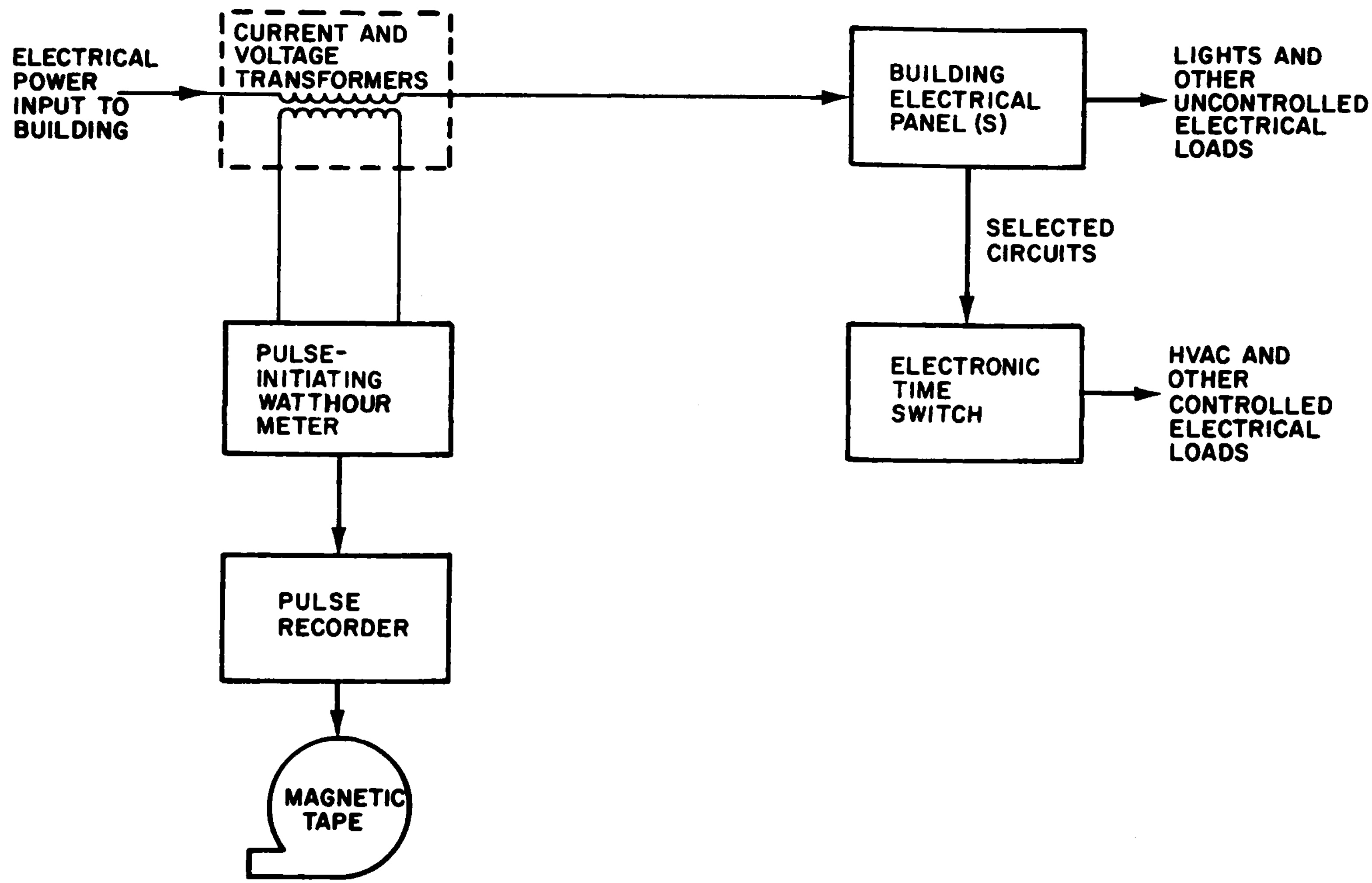


Figure 1. Typical electronic time switch and monitoring diagram.

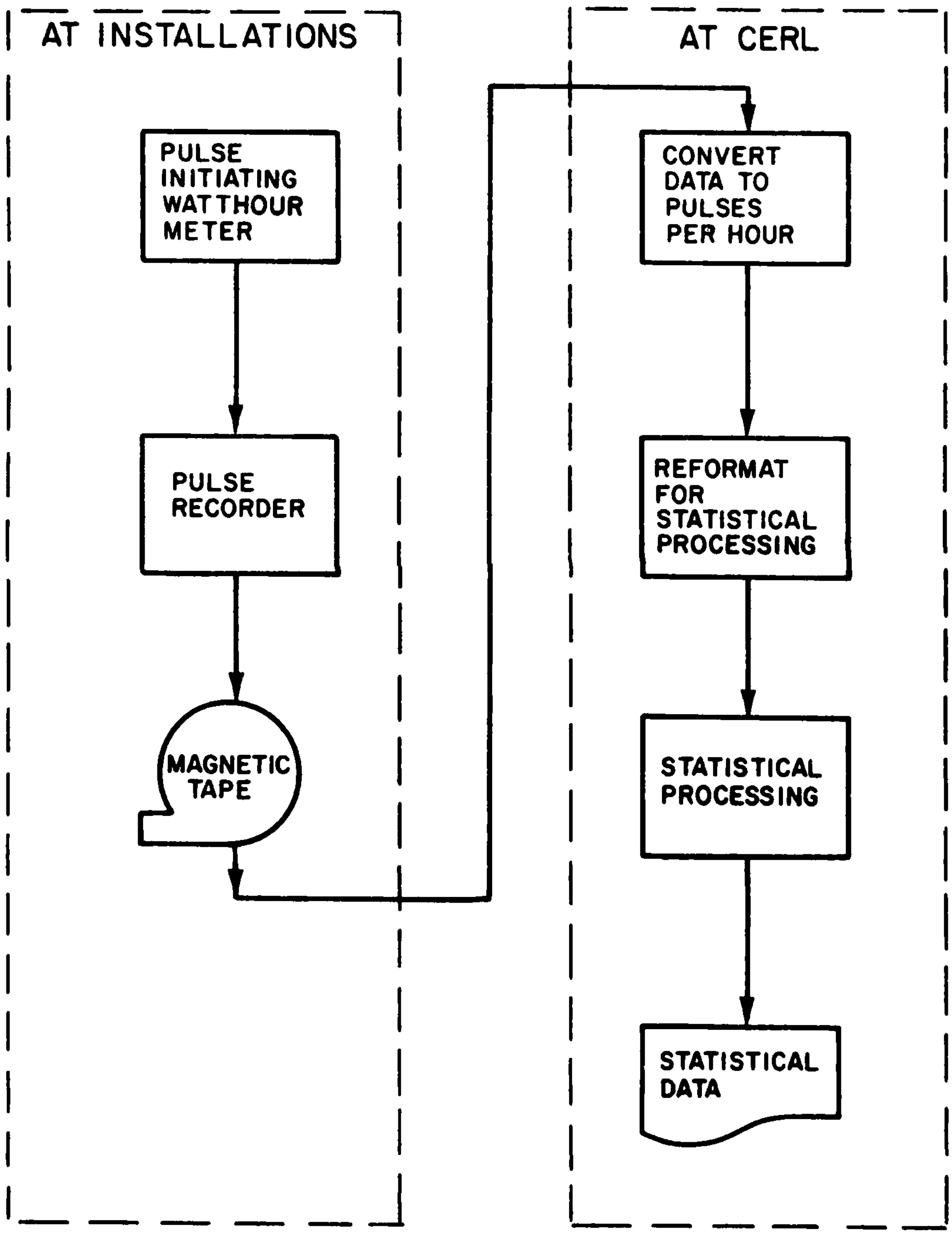
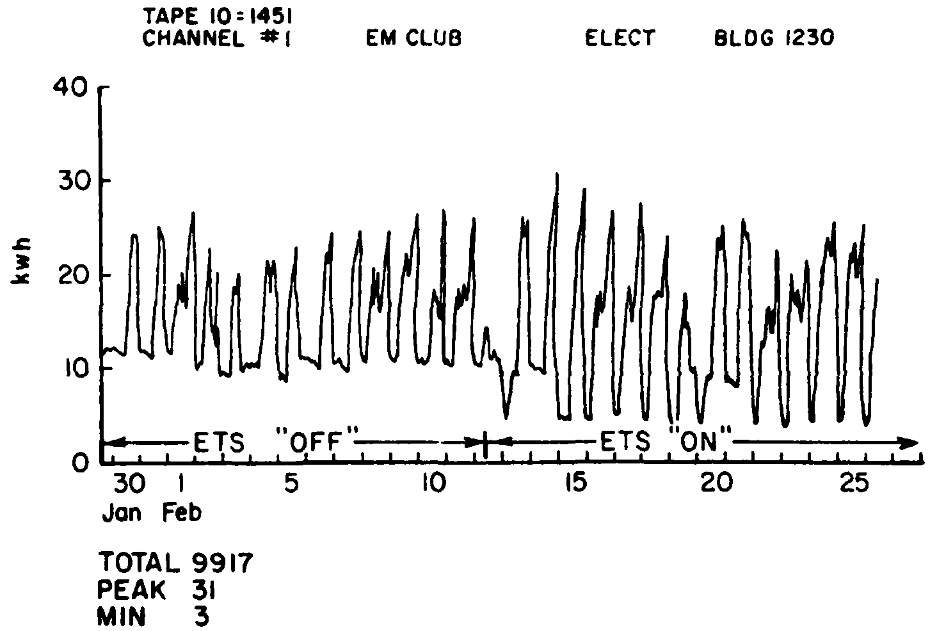


Figure 2. Data flow diagram.



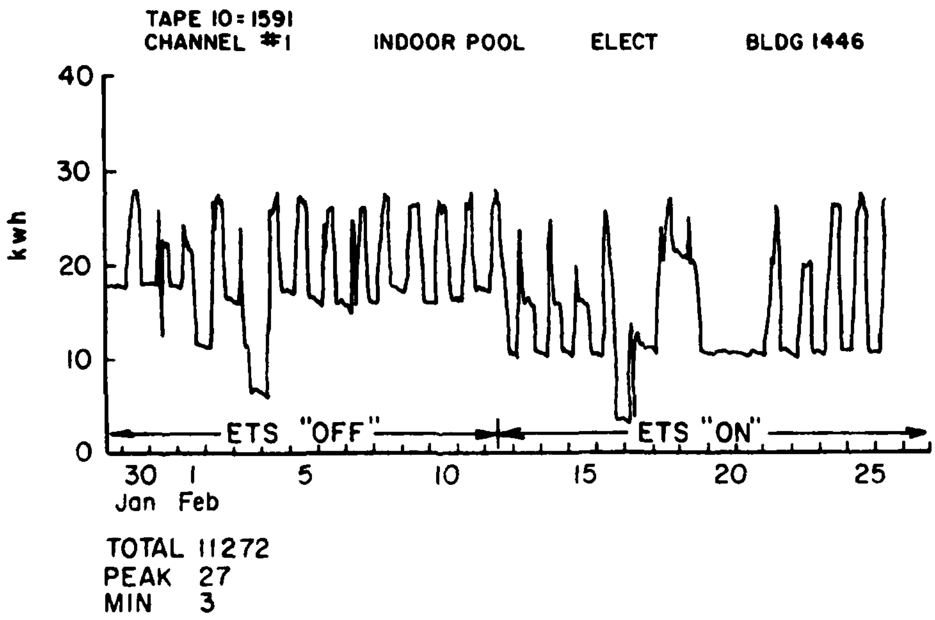


Figure 3. Typical monthly power consumption plots.

Table 3
Data Summary

Building No.	Days of Data	Average Daily Power Consumption "ON"	Average Daily Power Consumption "OFF"	Differences in kWh/Day	Estimated Savings Per Year kWh	Estimated Savings Per Year Dollars	Estimated Payback Period (Years)
Fort Carson							
1230	297	337	380	43	14,588	779	0.90
1354	347	292	350	58	21,248	1062	0.66
1446	397	385	433	48	17,496	875	0.80
1525	364	7595	7657	62	22,282	1124	0.62
1856	399	485	581	96	35,119	1756	0.40
2060	378	462	561	99	36,156	1808	0.39
2461	299	417	462	45	16,308	815	0.86
7304	400	377	436	59	21,479	1074	0.65
Fort Knox							
850	77	326	397	71	25,848	1292	0.54
1171	360	156	195	39	14,267	713	0.98
1172	270	93	105	12	4,380	219	3.20
6592	205	124	137	13	4,794	240	2.92

In the EM Club (Building 1230), two switches were installed to control air-handling units AHU-1, -2, -3, and -4. AHU-1 was turned off 49 hours per week, AHU-2, -3, and -4 were turned off 63 hours per week. The operation of th^ switches resulted in an average 43kWh per day reduction in electrical energy consumption. Over a period of 1 year, this would save about 14,600 kWh of electricity or $780 (assuming a cost of 5 cents per kWh).

Table 4
Average Daily Power Consumption by Weekday and Weekend and "ON"/"OFF" Time Periods (in kWh per day)

Building No.	Weekday "ON"	Weekday "OFF"	Weekend "ON"	Weekend "OFF"
Fort Carson				
1230	340	381	332	375
1354	290	349	296	352
1446	385	441	333	416
1525	8056	8124	6551	6630
1856	532	629	393	479
2060	536	595	343	485
2461	432	473	387	426
7304	376	422	380	459
Fort Knox				
850	326	395	324	400
1171	200	236	64	101
1172	123	131	30	46
6592	145	169	80	92

In the NCO Club Annex (Building 1354), a switch was installed to control the hot water pump, circulating pump, and the air-handling unit. The equipment was scheduled to be turned off 56 hours per week. The operation of the switches resulted in an average 58 kWh per day reduction in electrical energy consumption. Over 1 year, this would save about 21,250 kWh of electricity or $1,060.

In the indoor pool (Building 1446), a switch was installed to control the air-handling units, boilers, and the pool filtration circulating pump. The air-handling units were scheduled to be turned off 98 hours per week; the boilers and circulating pump were turned off 56 hours per week. The operation of the switch resulted in an average 48 kWh per day reduction in electrical energy consumption. Over 1 year, this would save about 17,500 kWh of electricity or $875.

In the main commissary (Building 1525), two switches were installed to control three air-handling units and the unit heaters in the warehouse and office areas. The equipment was scheduled to be off 28 hours per week. The operation of the switches resulted in an average 62 kWh per day reduction in electrical energy consumption. The air-handling units are a small portion of the total electrical load in a commissary as compared with other buildings. In a commissary, significant electrical energy is consumed by lighting in the sales area and cooling compressors for dairy, meat, and frozen food display cases and storage areas. Over

1 year this would save about 22,300 kWh of electricity or about $1125.

In a gymnasium (Building 1856), a switch was installed to control the air-handling units, which were scheduled to be turned off 64 hours per week. The operation of the switch resulted in an average 96 kWh per day reduction in electrical energy consumption. Over 1 year, this would save about 35,000 kWh of electricity or about $1750.

In the two-battalion headquarters and classroom building (Building 2060), a switch was installed to control air-handling units AHU-1 and -2, the hot and cold water pumps, and the hot water heater. AHU-1 and the cold water pump were scheduled to be turned off 111 hours per week. AHU-2 was scheduled to be turned off 121 hours per week, the hot water heater 123 hours per week, and the hot water pump 7 hours per week. The operation of the switches resulted in an average 99 kWh per day reduction in electrical energy consumption. Over 1 year, this would save about 36,000 kWh of electricity or about $1800.

In the mess hall (Building 2461), a switch was connected to air-handling units AHU-2 and -3. These units were scheduled to be turned off 56 hours per week. The operation of the switch resulted in an average savings of 45 kWh per day. Over 1 year, this would save about 16,000 kWh or about $800.

In the BOQ (Building 7304), a switch was connected to four zone pumps, a boiler, and a hot water pump. The zone pumps and boiler were scheduled to be turned off 56 hours per week and the hot water pump 28 hours per week. The operation of the switch resulted in an average of 59 kWh per day reduction in electrical energy consumption. Over 1 year, this would save about 21,500 kWh of electricity or about $1075.

Fort Knox

At Fort Knox, electronic time switches were installed in four buildings: (1) Building 850, a gymnasium; (2) Building 1171, a classroom building; (3) Building 1172, another classroom building; and (4) Building 6592, a battalion maintenance shop.

In the gymnasium (Building 850), a switch was installed to control two air-handling units. These units were scheduled to be turned off 49 hours per week. The operation of the switch resulted in an average of 71 kWh per day reduction in electrical energy consumption. Over 1 year, this would save about 26,000 kWh of electricity or about $1300.

In a classroom building (Building 1171), a switch was installed to control four air-handling units and two strip heaters. The equipment was scheduled to be turned off 98 hours per week. The operation of the switch resulted in an average of 39 kWh per day reduction in electrical energy consumption. Over 1 year, this could save about 14,250 kWh of electricity or about $710.

A second classroom building (Building 1172), also had a switch installed to control four air-handling units and two strip heaters. The operation of the switch resulted in an average 12 kWh per day reduction in electrical energy consumption. Over 1 year, this could save about 4,400 kWh of electricity or about $220.

In the battalion maintenance shop (Building 6592), a switch was installed to control the unit heaters. The heaters were scheduled to be turned off 93 hours per week. The operation of the switch resulted in an average 13 kWh per day reduction in electrical energy consumption. Over 1 year, this could save about 4800 kWh of electricity costing about $240.

During the test period, the switches were checked each month at the same time the data tapes were changed in the pulse recorders. Twice during this test, a switch had to be reprogrammed. In each case, the loss of the program was not equipment failure, but caused by maintenance personnel or building occupants.

Battery replacement is the only maintenance requirement for an electronic time switch. While no battery failures occurred during the test, batteries should be checked on a periodic basis; e.g., during the change to or from daylight savings time.

4 CONCLUSIONS AND RECOMMENDATIONS

This study concluded that:

1. Electronic time switches reduced electrical energy consumption in all 12 buildings used in the operational test. The estimated savings ranged from 4400 to 36,000 kWh per year. The estimated savings were calculated for electrical energy only and do not include savings realized from reduction of heating and cooling energy.

2. Electronic time switches can effectively conserve electrical energy when installed in buildings that have regular unoccupied periods or use equipment that can be turned off on a predetermined daily or weekly schedule.

3. Administrative buildings usually are the best candidates for switch installation, although any building without EMCS control and with HVAC equipment running 24 hours a day is a candidate.

4. Electronic time switches must be operating if they are to be effective. It is not unusual to find many buildings where timeclocks are installed and not operating. Many times they were disabled by building occupants who were uncomfortable or by maintenance personnel who responded to a complaint by disabling the system.

5. The payback period for electronic time switches ranged from 5 months to 3-1/4 years (Table 3).

It is recommended that Facilities Engineers review all buildings on their installations for the following criteria to determine if an electronic time switch should be installed:

1. The building is not under or planned for EMCS control.

2. The building has a regular occupancy schedule. Administration/training, production/maintenance building, and a community support facility are examples of buildings with a regular occupancy schedule.

3. The building is unoccupied at least 10 percent of the time, and the HVAC system can be turned off for at least 16 hours per week.

4. The building has a central HVAC system, preferably of a forced-air type.

If an electronic time switch is installed, the following precautions should be observed:

1. If low temperatures can damage the facility or its contents, a low-temperature thermostat (freezestat) must be installed to override the switch's operation.

2. The switch must be protected from vandalism or unauthorized adjustments.

3. The switch must be periodically inspected and maintained (usually when daylight savings times are changed) until more extensive data are obtained on maintenance requirements and standby battery life. The inspection should include a visual inspection for possible damage and a review of the time and program functions.

APPENDIX: CALCULATION OF ELECTRICAL ENERGY USE, BUILDING 1354, NCO CLUB ANNEX, FORT CARSON

Energy Use Assumptions

The following assumptions were made in calculating the electrical energy use in this building:

1. The building is open from 0700 to 2400 hrs weekdays, 0700 to 0100 Saturday, and 1200 to 2100 hrs on Sunday.

2. The lights in the main, music and lavatory rooms are on when the building is open for 112 hours per week.

3. The lights in the offices are on from 0700 to 1800 hrs on weekdays, from 0900 to 1600 hrs on Saturday and from 1200 to 1700 hrs on Sunday for a total of 78 hours per week.

4. The lights in the mechanical room are on 2 hours per day or 14 hours per week.

5. The lights in the main and music rooms are 50 percent delamped.

6. The lights in the office and toilet rooms are 25 percent delamped.

7. The receptacles in the main, music, and office rooms have a load equal to 25 percent of rated capacity.

8. The receptacles in the toilets have a connected load equal to 10 percent of rated capacity.

9. The mechanical room equipment receptacles have a connected load equal to 50 percent of rated capacity.

10. The sprinkler control has an intermittent load equal to 10 percent of capacity.

11. The HVAC equipment and pumps run at a power factor of 0.50 and cycle 50 percent of the time for a load factor of 25 percent.

12. The cabinet heater has a load equal to 25 percent of the rated load.

13. The receptacles are in use 2 hours a day at 50 percent of rated capacity.

14. The parking area lights are on 6 hours per day and were delamped by 50 percent.

15. The calculations were made using building plans. The plans may not incorporate all building modifications or equipment changes.

16. No attempt was made to estimate natural gas energy use.

Calculations

1. Calculated use per week (from work sheet)

Uncontrolled loads	996.8 kWh
Controlled loads	
Switch in use	865.2 kWh
Switch not in use	1300.8 kWh

2. Calculated total load per week

Switch in use	996.8 + 865.2 = 1862.0 kWh
Switch not in use	996.8 + 1300.8 = 2297.6 kWh

3. Calculated average load per day

Switch in use	1862.0 ÷ 7 =	266.0 kWh
Switch not in use	2297.6 ÷ 7 =	328.2 kWh

4. Estimated savings

Savings per day $328.2 - 266.0 =$ 62.2 kWh

Percentage savings $\frac{328.2 - 266.0}{328.2} = 19.0\%$

5. Measured average savings per day

Savings per day = 58 kWh

Percentage savings = 16.6%

WORKSHEET

CALCULATION OF ELECTRICAL ENERGY USE
BUILDING 1354 NCO CLUB ANNEX
FORT CARSON

FUNCTION	CIRCUIT NO.	Connected or Rated Load WATTS	HOUR/WEEK USED	% CAPACITY OR LOAD FACTOR	IS THIS A SWITCHED LOAD	UNCONTROLLED WEEKLY USE IN KWH	WEEKLY USE IN KWH SWITCH OFF	WEEKLY USE IN KWH SWITCH ON	
LIGHTS Main Room	1	1800	112	50	NO	100.8			
OFFICE LIGHTS	2	1600	78	75	NO	93.6			
MAIN ROOM LIGHTS	3	1800	112	50	NO	100.8			
MUSIC ROOM LIGHTS	4	1300	112	50	NO	72.8			
CONTROL LIGHTS	5	1600	112	75	NO	134.4			
TOILETS LIGHTS	6	1500	112	75	NO	126.0			
MAIN ROOM RECPT.	7	1000	112	25	NO	28.0			
MECH. ROOM LIGHTS	8	750	14	100	NO	10.5			
MAIN ROOM RECPT.	9	1000	112	25	NO	28.0			
OFFICE RECEPT.	10	800	78	25	NO	15.6			
TOILETS RECEPT.	11	1000	112	10	NO	11.2			
OFFICE RECEPT.	12	1000	78	25	NO	19.5			
MAIN ROOM RECPT.	13	1000	112	25	NO	28.0			
OFFICE RECEPT.	14	800	78	25	NO	15.6			
MECH. ROOM EQUIP.	15	250	112	50	NO	14.0			
MISC. RECEPT.	16	1000	112	25	NO	28.0			
SPRINKLER CONTROL	17	1000	112	10	NO	11.2			
MUSIC ROOM RECEPT.	18	1000	112	25	NO	28.0			
BOILER + PUMPS	19	400	168/112	25	YES		16.8	11.2	
CABINET HEATERS	20	170	112	25	NO	4.8			
HOT WATER PUMPS	21	500	168/112	25	YES		21.0	14.0	
SPARE	22	-0-							
SPARE	23	-0-							
SPARE	24	-0-							
CONTROLS	25	500	168	50	NO	42.0			
SPARE	26	-0-							
CONTROLS	27	500	168	50	NO	42.0			
TOILETS RECEPT.	28	1200	112	10	NO	13.4			
TOILETS RECEPT.	29	800	112	10	NO	9.0			
CLEANING RECEPT.	30	1000	14	50	NO	7.0			
PARKING LIGHTS	31+33	600	42	50	NO	12.6			
AIR HANDLING UNIT	32,34+36	7500	168/112	25	YES		315.0	210.0	
CONDENSOR	38,40+42	22500	168/112	25	YES		945.0	630.0	
		TOTALS				996.8	1300.8	865.2	

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1. Buildings -- electric equipment. 2. Buildings -- energy consumption. 3. Electric power consumption. I. Title. II. Series: Technical report (Construction Engineering Research Laboratory) ; E-184.

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